

AD-A108 378

SCIENCE AND EDUCATION ADMINISTRATION GAINESVILLE FL --ETC F/8 6/6
EVALUATION OF INSECTICIDES, CLOTHING REPELLENTS, AND OTHER APPR--ETC(U)
NOV 81 D L KLINE, R H ROBERTS

N00014-79-F-0070

NL

UNCLASSIFIED

1-1
1-1



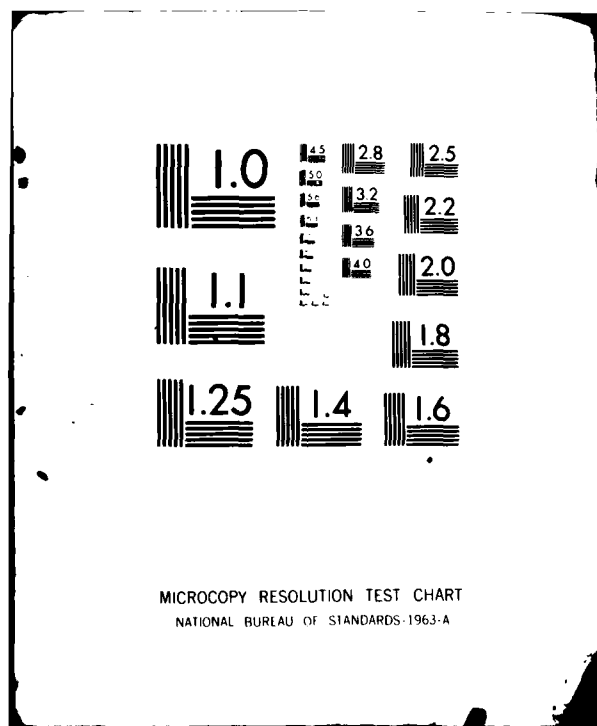
END

DATE

FILED

62

NTIC



AD A108378

DTIC FILE COPY

LEVEL II

12

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ANNUAL REPORT No. 2	2. GOVT ACCESSION NO. AD-A108378	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Evaluation of Insecticides, clothing repellents, and other approaches to the control of coastal sand flies, <i>Culicoides</i> spp.		5. TYPE OF REPORT & PERIOD COVERED Annual-Oct. 1, 1980 to Sept. 30, 1981
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Daniel L. Kline and R. H. Roberts P.O. Box 14565 Gainesville, Florida 32604		8. CONTRACT OR GRANT NUMBER(s) N0014-79-F-0070
9. PERFORMING ORGANIZATION NAME AND ADDRESS Insects Affecting Man and Animals Research Laboratory		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR 133-997
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Code 443 800 N. Quincy Street Arlington, Virginia 22204		12. REPORT DATE 01 November 1981
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Same as 11.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) DEC 09 1981		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Seasonal population dynamics, <i>Culicoides</i> spp., treated screens, habitat characterization, laboratory developmental studies, artificial membrane, field ground and aerial ULV.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		

DD FORM 1473
1 JAN 73EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

LB

20. ABSTRACT

Population dynamics and control studies on *Culicoides* sand flies were continued at Parris Island, South Carolina, and Yankeetown, Florida.

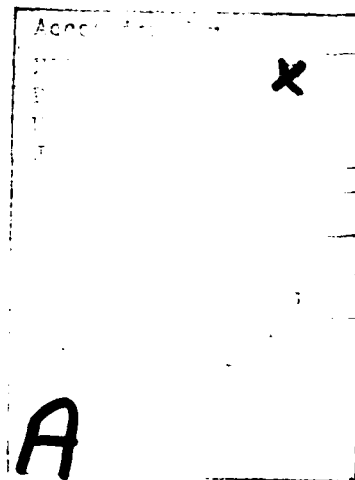
Adult seasonal patterns were monitored by NJ light traps. Five species, *C. barbosai* Wirth and Blanton, *C. furens* (Poey), *C. hollensis* Melander and Brues, *C. melleus* (Coquillett), and *C. mississippiensis* Hoffman are considered abundant. *C. barbosai*, *C. furens* and *C. melleus* are present from mid-April through late October; *C. hollensis* and *C. mississippiensis* peak in the spring and fall of the year. A comparison of several population survey techniques indicated that CDC-type traps baited with CO₂ gas and used in conjunction with New Jersey traps should give a reliable estimate of *Culicoides* activity during chemical control tests.

Twenty-one different larval habitats were identified at Parris Island. Areas along the upland edge of the salt marshes and areas underneath large logs which had fallen into the marsh consistently yielded larvae, while *Salicornia* and denuded panne areas seldom yielded any larvae. At Yankeetown fluctuations in larval density were correlated with plant cover. Based on mean number larvae/sample, substrate samples taken from *Distichlis* areas yielded the greatest number of larvae followed in decreasing order by *Spartina* and *Juncus* areas. These data suggest that a properly timed effective larvicide could reduce adult emergence by 53% by treating 30% of the marsh. Remote sensing techniques were used to locate and quantify breeding sites.

In laboratory studies, 20°C was the optimum temperature for development (57 days) of *C. mississippiensis*. Reared females were 100% autogenous. Techniques were developed to blood-feed *C. mississippiensis* through a cloth-reinforced silicone membrane on bovine blood; there was no significant decrease in egg production compared to that of females fed on a human host.

In chemical control studies, laboratory treated screens, field ground ULV and aerial ULV tests were conducted. NRDC-161 and permethrin gave ca. 100% mortality 168 days after the screens were treated at .125% A.I. (wt/vol. technical in acetone) for NRDC-161 and at .5% for permethrin. Ground ULV tests against *C. mississippiensis* with resmethrin gave indeterminate results, and aerial ULV tests with half the label dosage rate of naled at Parris Island gave a disappointing level of control. In both of these spray tests the level of control was probably due in part to insufficient penetration of spray in vegetated areas.

Deet-treated net jackets were tested in Panama and provided ca. 90% protection.



SUMMARY

Population dynamics and control studies on *Culicoides* biting midges (sand flies) were continued at Parris Island, South Carolina, and Yankeetown, Florida.

Adult seasonal patterns were monitored by modified New Jersey light traps. Three species (*C. furens* Poey, *C. hollensis* Melander and Brues, and *C. melleus* (Coquillett) at Parris Island and 3 species (*C. barbosai* Wirth and Blanton, *C. furens* and *C. mississippiensis* Hoffman) at Yankeetown are considered major pests. *C. barbosai*, *C. furens*, and *C. melleus* have several peaks from mid-April through late October. Both *C. hollensis* and *C. mississippiensis* peak in the spring and fall of the year. At Yankeetown, fifteen other species were collected infrequently, and comprised <1% of the total trap collections.

A comparison of several trapping methods (Malaise, CDC traps baited with CO₂ gas, unbaited CDC traps, and New Jersey light traps) was done at Parris Island to determine their reliability to assess the effects of ground and aerial ULV sprays on natural populations. From this comparison study, we concluded that baited CDC traps used in conjunction with N.J. traps should give a reliable estimate of any adult *Culicoides* activity at Parris Island.

Larval habitat characterization studies were conducted at Parris Island and Yankeetown. At Parris Island the emphasis was placed on identifying all the different potential habitats. Twenty-one different types of habitats were identified, of which 2 consistently yielded larvae (upland edge of the marsh shaded by live oaks and/or water oaks; and beneath large logs which have fallen out into the marsh), and 2 areas which yielded practically no larvae (*Salicornia* and completely denuded panne areas).

At Yankeetown the emphasis was placed on completing the study on population fluctuation of immatures within a gridded 125 m X 425 m section of typical salt marsh which contained three main vegetative types (*Juncus*, *Spartina*, and *Distichlis*). Based on the mean number of larvae/sample, overall substrate samples taken from *Distichlis* areas yielded the greatest number of larvae followed in order by samples taken from *Spartina* and *Juncus* areas. The study area, however, was composed of ca. 70% *Juncus*, 23% *Spartina*, and 7% *Distichlis*. When this factor is taken into account, the overall projection for FY81 was that *Juncus* would account for 62%, *Spartina* 28%, and *Distichlis* 9% of the larvae recovered. If this study area is truly typical of salt marshes in the vicinity of Yankeetown, then a potential 38% reduction in the adult population could be achieved by treating 30% of the marsh area with an effective larvicide. If the correct month for treatment were selected, such as February, up to 53% of the larvae could be killed by treating the same 30% of the marsh.

Studies to determine the feasibility of using remote sensing techniques to locate and quantify breeding sites was initiated in February, 1980. Two remote sensing flights over the salt marsh grid area at Yankeetown, and one over Parris Island were flown by the 363rd TRW/DOO, Shaw AFB, South Carolina.

In the laboratory, *C. mississippiensis* was successfully reared at 15°, 20°, and 25°C. Development times were inversely related to temperature. The optimum temperature for rearing was 20°C. Complete development at this temperature required a total of 57 days. Reared females were 100% autogenous and matured an average of 123 eggs. Blood-fed wild females with the same wing length as the reared females matured an average of 35 eggs.

Techniques were developed for blood-feeding field-collected *C. mississippiensis* on preserved bovine blood through a cloth-reinforced silicone membrane. There was no significant difference ($p < 0.05$) between the numbers of eggs matured by females which had fed on a human host (40 ± 11) or through the membrane on bovine blood (36 ± 13).

Two synthetic pyrethroids, permethrin and NRDC-161 (Decamethrin ®) were evaluated for their effectiveness as residual screen treatments to prevent entry of *C. mississippiensis* into screened areas. NRDC-161 was the most effective with screens treated with this insecticide still causing ca. 100% mortality at all concentrations tested (.125, .25, 15, and 1.0% A.I. (wt./vol.) 168 days after they were treated. Permethrin gave comparable results at .5 and 1.0%.

Ground ULV tests against natural *C. mississippiensis* populations at Yankeetown with resmethrin gave indeterminate results. There was some indication that the field population was reduced, but there was high variability in the collection numbers and in the mortality of caged mosquitoes and biting midges. Two major problems in achieving control appear to be timing the spray application and penetrating the vegetative cover which, when dense, appears to restrict movement of the aerosol through the area.

During the period of 1-9 April, 1981 a joint USDA-DOD research project at the Marine Corps. Recruit Depot, Parris Island, South Carolina, was conducted to develop and evaluate aerial application of naled (Dibrom 14 ®) and HAN for *Culicoides* biting midge control. One of the goals in this first trial was to test the use of an application rate lower than the maximum allowable rate in order to reduce costs and the possibility of environmental damage. Valuable results and information were obtained even though the level of control achieved was somewhat disappointing. Collections from surveillance traps indicated that the spray had a significant impact on the natural population of biting midges on Parris Island when compared to the untreated area surveyed on nearby Lemon Island.

Although the population in both areas actually increased on the day following treatment, the post-treatment population of biting midges on Parris Island was approximately 50% lower than those on Lemon Island. The effects of the spray were also monitored using caged mosquitoes and biting midges. Results of this bioassay indicated an overall 67% kill of caged mosquitoes and 58% kill of caged biting midges. This level of control was probably due in part to insufficient penetration of the spray in vegetated areas. In support of this view the kill of caged mosquitoes placed in open or sparsely vegetated areas was 87%, while the mortality in cages placed in dense vegetation was only 40%. Although the number of caged *Culicoides* was somewhat limited, the *Culicoides* kill was also better in open areas. The low dose of chemical (1/2 oz/A) applied was possibly insufficient to give good penetration through vegetation. Other environmental factors, such as marginally high winds and low temperatures during the application, could have adversely affected the treatment.

Light-weight net jackets treated with N, N-diethyl-*m*-toluamide (deet) were field-tested in Panama against 5 species of biting midges, principally *C. furens* and *C. barbosai*. The jackets provided ca. 90% protection.

Area treatment tests with deet impregnated netting were initiated at Yankeetown. These investigations are expected to be completed in 1982.

I. INTRODUCTION

This report summarizes research activities on *Culicoides* biting midges (sand flies) conducted at Parris Island, South Carolina, and Yankeetown, Florida during FY81. Population studies were continued to complement the first year's studies. In the chemical control studies emphasis shifted from laboratory screening to field testing.

II. POPULATION DYNAMICS AND BIOLOGICAL STUDIES

Seasonal Patterns of Adults

Seasonal population studies of adult *Culicoides* were continued at Parris Island, South Carolina, and Yankeetown, Florida. New Jersey light traps, modified by replacing the standard delivery cone with 40-mesh brass screening, were used at both sites. Data were obtained on species composition, seasonal incidence, and relative abundance.

At Parris Island, four New Jersey light traps were operated nightly. Samples were retrieved from the field at least twice weekly (3- and 4-day intervals). Trap catch results for the period October 1, 1980 through September 30, 1981 are listed in Table 1. Three species *C. furens*, *C. hollensis* and *C. melleus* are considered major pest species at this location. *C. furens* was abundant during October and from April through September. This species was most abundant from the last week in April through the first week in June. *C. hollensis* was abundant in light trap collections for the month of October with occasional specimens collected from November through February and was then very abundant from mid-March until the end of May. Thereafter, *C. hollensis* was virtually absent from light trap collections until the last week in September. *C. melleus* was abundant during the month of October and then was not collected again until the last week in March. This species reached its spring peak in April, then remained at low levels throughout the summer months and reached a fall peak during the first week of September.

At Yankeetown, two modified New Jersey light traps were operated nightly. Samples were retrieved from the field at approximately weekly intervals. Three species, *C. mississippiensis*, *C. furens* and *C. barbosai* were abundant, and trap catch results for these species for October 2, 1980 through September 30, 1981 are listed in Table 2. Fifteen other *Culicoides* species (Table 3) were collected infrequently; these comprised < 1% of the total trap collections. Trap downtime due to malfunction, vandalism, and other causes was less than 10%.

C. mississippiensis was present throughout the year, but abundant only in spring and fall. Data from Table 2 show a sharp rise in abundance during November-early December and a second rise beginning in February and peaking in May-early June. Compared with the previous year's data, the fall peak occurred slightly later and the spring peak was slightly more protracted. *C. furens* adult abundance peaked in May-June and August-September. These species seasonal patterns are very similar to last year's. Abundance of *C. barbosai* paralleled that of *C. furens* but on a lesser scale.

Comparison of Techniques for Trapping Adult *Culicoides* spp.

In order to evaluate the effectiveness of any control procedure there is a need to establish a survey method that gives reliable estimates of populations. Since many survey techniques are available to collect adult *Culicoides*, we decided to evaluate several at Parris Island to determine their reliability in monitoring the effectiveness of ground and aerial ULV sprays.

In fall 1980 we compared unbaited U.S. Army miniature solid state type CDC light traps with our standard adult population assessment trap, the modified New Jersey traps mentioned above. A complete description of this CDC trap can be found in Driggers et al. (1980). The trap is automatically activated at dusk in response to decreasing ambient light conditions. Once activated, the motor and lamp operate continuously until the power supply is disconnected. Twelve CDC traps were used. The New Jersey traps were controlled by automatic timers which were adjusted so that these traps were active for the same time period as the CDC traps.

Trap locations for the New Jersey traps remained the same as in our seasonal population assessment program. The CDC traps were placed in similar areas where *Culicoides* were known to be a problem, based either on personal experience or complaints by recruits, and were distributed in such a way that the entire base was surveyed. The holding device in both type traps was the kill jar, which consisted of a glass pint mason jar containing a small strip of Shell No-Pest Strip ®.

All three major pest species, *C. furens*, *C. hollensis*, and *C. melleus*, were collected (Table 4). It was observed that within reasonable limits, the trends were similar for both types of traps. The New Jersey traps generally caught more specimens, which was expected since it used a 40-watt light bulb as opposed to the miniature 6 volt lamp used in the CDC trap. For *C. furens* and *C. melleus*, the collections in both traps accurately reflected biting complaints. For *C. hollensis*, however, in the latter part of October throughout the rest of the sampling period light trap collections were inconsistent with biting complaints. A possible explanation was that since these traps were activated at dusk and ceased activity at dawn, the ambient temperature was too low for flight to occur during this time period. We have observed, as have other investigators, that *Culicoides* flight activity ceases below 55°F.

Further studies were conducted in spring 1981. In this study four types of traps were used: 4 modified New Jersey traps, 6 unbaited and 6 CO₂ gas-baited (200^{ml}/min) army-type CDC traps, and a fine mesh Malaise trap. A different strategy from the fall study was employed, in that all the traps were operated continuously during any 24 hr period. From mid-March to mid-April, when *C. hollensis* was the predominant species, the temperature, at dusk, was < 60°F, usually below 55°F. Within this time interval the baited CDC trap collected more than any of the other traps with a few exceptions when the Malaise trap collected more. Once the temperature remained consistently greater than 55°F. at dusk, the collections in the unbaited CDC and New Jersey traps increased and similar trends were noted for *C. hollensis* by all 4 trapping methods.

From mid-April through June, *C. furens* was the predominant species. Generally, this species is present during the time of year when warmer evening temperatures occur. Peak activity normally occurs around dusk and dawn. Consequently, the baited CDC and New Jersey traps showed similar trends. The unbaited CDC and malaise trap collections showed inconsistent trends; based on the collections in the fall, 1980 test, we are unable to explain these poor collections.

From these data we conclude that baited CDC traps used in conjunction with our New Jersey traps should give a reliable estimate of any adult *Culicoides* activity at Parris Island.

Studies of Immature Populations

At Parris Island a search for larval habitats was initiated in December with emphasis on identifying all possible breeding sites. To date, twenty-one different types of potential habitats have been investigated (Table 5). Two habitats that consistently yielded larvae were the upland edge of the marsh shaded by live oaks or water oaks, and beneath large logs which had fallen out into the marsh. Samples taken from these types of areas in past years, had also consistently yielded larvae. Areas covered with *Salicornia* or completely denuded (panne and mudflats within tidal creeks) did not produce many larvae.

At Yankeetown the larval habitat characterization studies initiated last year were continued within a 125m X 425m section of typical salt marsh. This study area was subdivided into eighty-five 625m X 425m plots. Each plot was characterized according to the different vegetative types found *Distichlis*, *Juncus*, and *Spartina* and various mixtures of these grasses. Sod samples (ca. 10cm diam. X 8cm deep) were taken weekly from each major vegetative cover by means of post hole diggers. The location of each sample was determined through random selection of the plots in which the desired vegetation type is found.

The data collected at Yankeetown between October 1, 1980, and September 30, 1981 are shown for the major vegetative types in Table 6. Fifty sample dates yielded 1486 samples and 15,207 larvae. Compared to FY80 results, larvae were more abundant in all three vegetative areas. For 7 months of the year *Distichlis* samples yielded the highest mean number larvae/sample, and for the remaining 5 months *Spartina* areas yielded the highest mean number larvae/sample. With the exception of July, samples taken from *Juncus* dominated areas always yielded the least number of larvae.

Overall, based on the mean number larvae/sample, *Juncus* areas yielded 26%, *Spartina* areas 36% and *Distichlis* areas 38% of the larvae recovered. These figures would imply that *Spartina* and *Distichlis* account for 74% of the larvae produced at this marsh site. These figures, however, need to be adjusted to reflect the relative abundance of these 3 vegetative types within our study area. From aerial photographs, followed by ground truthing, the study area was calculated to be composed of ca. 70% *Juncus*, 23% *Spartina*, and 7% *Distichlis*. Therefore, a readjustment of the mean number of larvae recovered from each vegetative type acquired through sampling must be made to account for the disproportionate area each type occupies within the marsh. When this adjustment is made, the overall projection for the entire year shows that *Juncus* would account for 62%, *Spartina* 29% and *Distichlis* 9% of the larvae recovered from this marsh in FY81. If these population projections, based on our grid sampling, are typical for all the marshes in the Yankeetown area, then a potential 38% reduction in the subsequent adult population could be achieved by treating 30% of the marsh area with an effective larvicide. An even greater reduction can be achieved if these same areas are treated in the proper month. For example, a glance at Table 6 would indicate that February would be a good month to treat. If an effective larvicide were applied to these areas in February, 53% reduction could be achieved.

Remote Sensing Techniques for Population Distribution

Our studies on the population dynamics and habitat characterization for *Culicoides* included aerial surveys during the last year. Two remote sensing flights of our salt marsh grid area at Yankeetown, and one over Parris Island were flown by the 363rd TRW/DOO, Shaw AFB, South Carolina. The objective was to determine the feasibility of this technique to locate and quantify the various vegetative types. These flights indicate that aerial photography, especially infrared techniques, can be used to quantify the amounts of different types of plants in an area. Therefore, we feel that remote sensing techniques, coupled with reliable ground-truth data, will provide a rational approach for assessment of biting midge production in a given geographic area and therefore aid in their control.

Laboratory Studies on Life Cycle of *C. mississippiensis*

Development of *C. mississippiensis* was successful at 15°, 20°, and 25°C, but not at 10° or 30°C. Development times were inversely related to temperature. The optimum temperature for rearing was 20°C at which complete development required a total of 57 days. The egg stage lasted 8 days, the larval stage 40 days, the pupal stage 5 days, and the adult pre-oviposition time 4 days. Reared females were 100% autogenous and matured an average of 123 eggs. Blood-fed wild females with the same wing length as the reared females matured an average of 35 eggs. Engorgement with blood required 4 min 19s (S.D. = 19s).

Use of Artificial Membrane for Feeding Adults

Techniques were developed for the preparation and use of a reinforced silicone membrane in laboratory blood-feeding of *C. mississippiensis* on preserved bovine blood. The membrane was made from Sears Clear Silicone Glue and Seal © # 9-80672 rolled over a piece of polyester organdy cloth. In 12 feeding trials conducted on 4 dates, the mean feeding percentage was 77.6% (S.D.= 9.2%). Production and hatch of eggs from females fed on bovine blood through the membrane were compared to that of females captured on the same dates but allowed to feed to repletion on a human forearm. There were no significant differences ($p < 0.05$) between numbers of eggs matured by females which had fed on a human host (40 ± 11) or through the membrane on bivine blood (36 ± 13).

III. CHEMICAL CONTROL STUDIES

Evaluation of Treated Window Screens

Two synthetic pyrethroids, permethrin and NRDC-161 (Decamethrin ©), were tested at .125, .25, .5 and 1.0% A.I. (wt./vol. technical in acetone) in evaluations of their effectiveness as residual screen treatments to retard or prevent entry of *C. mississippiensis* adults into screened areas. Discs (9cm diameter) of standard aluminum screen (16 by 18 mesh) were treated by immersion for ca. 10 seconds in the solution. After treatment, the screens were hung under a shelter, designed to produce the effects as if they were hung beneath the eaves of a building to dry. Control tests were conducted with screens immersed in acetone only. Exposure techniques were identical to those described in the previous Annual Report (1980) NRDC-161 was the most effective with screens treated with this insecticide still causing ca.

100% mortality at all concentrations tested 168 days after they were treated. After 168 days, we had difficulty trapping flies for testing. Based on these results, a single treatment of this chemical should give complete protection for an entire *C. mississippiensis* season. Permethrin treated screens at .125% gave < 50% mortality 1 day after treatment. At .25% ca. 90% mortality was produced for at least 56 days post-treatment. At .5 and 1.0% ca. 100% mortality was achieved for the entire 168 day period that the screens were tested.

Ground ULV Tests

Ground ULV tests were initiated at Yankeetown, Florida, against natural *C. mississippiensis* populations with resmethrin. Effectiveness of the ground ULV sprays was assessed by population monitoring with CDC light traps baited with CO₂, caged mosquitoes, caged biting midges, and cages with both mosquitoes and biting midges. The combination was necessary in order to test spray penetration of the small mesh screen used to confine the biting midges. Two tests were conducted. The resmethrin was sprayed at the rate of 0.007 lb/acre. In the first test, the spray was delivered at 4 oz/min at 10 mph and in the second test at 9.2 oz/min at 10 mph.

The results were indeterminate. In test one, high mortality was obtained in all cages at two locations, and slight to no mortality at the other locations. In test two, high mortality in the control cages negated the test cage results. While there was some indication that the field population was reduced, high variability in collection numbers prevented accurate assessment.

One major problem in achieving control appears to be the timing of spray application. *C. mississippiensis* is active for several hours before sunset, therefore, treatments were made between 5 and 6 PM, ca. 2 hours before sunset. At this time of day, thermal air currents, especially over those sections of the road exposed to the sun, prevented proper aerosol dispersion. A second factor in obtaining adequate coverage with ground ULV equipment is the influence of the vegetative cover which, when dense, appears to restrict movement of the aerosol through the area.

Aerial ULV Tests

An aerial application test for control of *Culicoides* at Parris Island was conducted on April 7, 1981 using the conventional insecticide naled (Dibrom-14). Two Air Force UC-123-K aircraft applied the insecticide using techniques normally employed for mosquito adulticiding. However, the insecticide was applied in two treatments spaced ca. 20 minutes apart using 2 aircraft to take advantage of any "flushing action" on the insect population caused by the first application. Each of the two treatments applied a 1:5 mixture of Dibrom-14:HAN (Heavy Aromatic Naptha) at a rate of 1.5 oz/A which included 1/4 oz /A HAN. This resulted in a total application rate of 1/2 oz/A of Dibrom-14 which is the minimum dose recommended for adult mosquito control. The entire land and marsh area of Parris Island (ca.8000 acres) was treated. The aircraft were equipped with Tee Jet nozzles oriented 45° forward and were flown at 140 kts airspeed, 2,000 ft swath width and 200 to 250 ft. altitude. Meteorological data during the insecticide applications were collected by a weather team from the Marine Corp. Air Station, Beaufort, South Carolina. (Table 7). Winds were generally easterly with a speed of ca. 7 kts on the ground. Wind speed aloft increased somewhat during

the spray operation from ca. 8 kts, at 200' 30 minutes prior to the start of spraying to ca. 14 kts at 200' 30 minutes after the start of spraying. The effectiveness of the insecticide treatment was determined by measuring the population by surveillance traps and by bioassays with caged insects.

Several trapping methods were employed at different locations on Parris Island and in an untreated control area on nearby Lemon Island to monitor the natural population. CDC light traps baited with CO₂ and operated continuously (day and night) provided the best population indicator for *C. hollensis*, which was the predominant species present during this study. This species had peak activity periods that included some daylight hours during the morning and afternoon. Trap collections were collected and counted twice daily (early morning and afternoon) to quantitate activity peaks. Six CO₂-baited CDC traps were operated on Parris Island and 2 on Lemon Island. The traps were placed 4 ft. above ground on metal stakes. CO₂ gas cylinders at a flowrate of 200 cc/min, which was measured by a floating ball flowmeter on each trap. The traps were operated for 10 days pre-treatment and 1 day post-treatment.

Caged *Aedes taeniorhynchus* females (25/cage) were used in the treated area as an indicator of insecticide distribution and effectiveness. A total of 65 cages of mosquitoes were placed on 4 ft stakes throughout Parris Island with 56 cages along roadways at 0.1 mile intervals and the remainder placed at trapping stations. A limited number of caged sand flies (11 cages with ca. 100/cage) was also placed in the treated area. The sand flies were field-collected using a modified CDC trap baited with CO₂ gas and then released onto a lighted window and aspirated into cages consisting of 1/2 pint cylindrical paper cartons with 40 ga screen wire on the top and bottom.

Results of the natural population surveys and caged insect bioassays indicated that only a low level of control resulted from the aerial application. The surveillance traps indicated that the population level actually increased in both the treatment and control areas; however, the population level in the treated area was ca. 50% lower than the level in the control area. Since the pre-treatment population levels for both areas had been nearly the same this suggests that the insecticide achieved around 50% mortality in the treated area. This agrees with the results of the caged insect bioassays where the overall mortality in caged mosquitoes was 67% and in caged sand flies it was 58%.

A number of factors probably contributed to the low level of control. We feel that one important factor was insufficient penetration of the spray in vegetated areas. This was indicated since the kill of caged mosquitoes placed in open or sparsely vegetated areas was 87%, while only 40% kill was noted in cages protected by dense vegetation. Although the number of caged sand flies was limited, their mortality was also greater in open areas. The low dose of chemical applied in this test was possibly insufficient to give good penetration of the vegetation. Other environmental factors such as marginally high winds and low temperatures during the application could have adversely affected the treatment.

IV. PERSONAL PROTECTION

Light-weight net jackets treated with *N,N*-diethyl-*m*-toluamide (deet) were field-tested in Panama against 5 species of biting midges, principally *Culicoides furens* (Poey) and *C. barbosa* Wirth and Blanton. The deet-treated jacket provided 87 to 93% protection. Morning and evening tests as well as time of year appeared to influence the proportionate numbers of species present. The mean coefficient of protection was slightly lower during morning tests when *C. barbosa* was most abundant and higher during evening tests when *C. furens* was most abundant.

Area treatment tests with deet impregnated netting were initiated at Yankeetown, Florida. PVC pipe (1" diameter) was used to construct 2 units, each 2 m² and 2 high. The sides of the units were covered with netting and the tops were left open. The netting of one unit was treated with deet and the other left untreated. A sticky trap baited with CO₂ gas (.5l/min) was set up in the center of each unit and daily counts were made of the biting midges trapped. Periodically, 1 or 2 subjects made biting counts inside and outside the units. These units were tested daily until they failed to provide any protection from blood-seeking female biting midges. An outside sticky trap was also set up ca. 75 m away from either cage. These investigations are expected to be completed in 1982.

REFERENCES CITED

Driggers, D. P., O'Connor, R. J., Kardatzke, J. T., Stup, J. L. and Schiefer, B. A.,
1980. The U.S. Army Miniature Solid State Mosquito Light Trap. Mosquito
News 40:172-178.

BIBLIOGRAPHY OF PUBLICATIONS/MANUSCRIPTS
PREPARED UNDER THIS CONTRACT FY 1981

PUBLICATIONS

- Kline, D. L. and R. H. Roberts. 1981. Effectiveness of clyorpyrifos, fenthion, malathion, and propoxur as screen treatments for control of *Culicoides mississippiensis*. J. Econ. Entomol. 74:331-333.
- Kline, D. L., R. H. Roberts, and D. A. Focks. 1981. Extraction of larvae of the ceratopogonid biting midge, *Culicoides mississippiensis*, from salt marsh soils with a new agar technique. Mosquito News 41:94-98.
- Schreck, C. E. and D. L. Kline. 1981. Repellency determinations of four commercial products against six species of ceratopogonid biting midges. Mosquito News 41:7-12.
- Roberts, R. H. and D. L. Kline. 1981. Efficacy of insecticide-treated screens against biting midges (Diptera:Ceratopogonidae), *Culicoides* spp. Proc. Fla. Anti-Mosq. Assn. 51(2):41-43.
- Kline, D. L. 1981. Current status of *Culicoides* research at the USDA Laboratory in Gainesville, Florida. Proc. Fla. Anti-Mosq. Assn. 51(2):71-75.

MANUSCRIPTS

- Kline, D. L. and R. H. Roberts. Daily and seasonal abundance of *Culicoides* spp. biting midges in selected mangrove areas in Lee County, Florida, (submitted to Florida Entomologist).
- Kline, D. L., D. G. Haile and K. F. Baldwin. Wind tunnel tests with seven insecticides against adult *Culicoides mississippiensis* Hoffman (accepted by Mosquito News).
- Harlan, H., C. E. Schreck and D. L. Kline. Insect repellent jacket tests against biting midges (*Culicoides* spp.) in Panama. (submitted to American Journ. Trop. Medicine and Hygiene).
- Davis, E. L., J. F. Butler, R. H. Roberts, J. F. Reinert, and D. L. Kline. Laboratory blood-feeding of *Culicoides mississippiensis* Hoffman through a reinforced silicone membrane. (Submitted to J. Med. Entomol.).

THESIS

- Davis, E. L. 1981. Laboratory studies on life cycle development and adult blood-feeding of *Culicoides mississippiensis* (Diptera:Ceratopogonidae). M. S. University of Florida, 107 pp.

Table 1.--Avg. no. (per trap/night) of *Culicoides* spp. collected at 4 locations at Parris Island, South Carolina

Trapping dates :		Number of <i>Culicoides</i> ^{a/} at indicated location															
:		Horse Island				Elliott Beach				Rifle Range				Gardens			
:		f	h	me	f	h	me	f	me	f	h	me	f	h	me	f	me
Date																	
1980																	
Oct	01-07	56	328	29	35	46	5	4	13	<1	6	6	<1	6	<1		
	08-14	272	1366	182	1282	1080	442	60	365	73	43	187	7	7			
	15-21	183	757	449	1023	1957	50	77	1143	125	43	156	11	11			
	22-28	19	180	16	140	504	10	34	1781	20	8	66	3	3			
Oct/Nov																	
	29-04	11	174	<1	79	361	0	15	273	0	1	14	0	0			
	05-11	0	142	<1	<1	13	0	0	20	0	<1	14	0	0			
	12-18	0	21	0	0	107	0	0	12	0	0	7	0	0			
	19-25	0	4	0	0	6	0	0	1	0	0	2	0	0			
Nov/Dec																	
	26-02	0	4	0	0	38	0	0	0	0	0	5	0	0			
	03-09	0	<1	0	0	<1	0	0	<1	0	0	1	0	0			
	10-16	0	<1	0	0	<1	0	0	<1	0	0	<1	0	0			
	17-23	0	<1	0	0	<1	0	0	0	0	0	0	0	0			
	24-30	0	<1	0	0	<1	0	0	<1	0	0	<1	0	0			
1981																	
Dec/Jan	31-06	0	<1	0	0	<1	0	0	0	0	0	0	0	0			
	07-13	0	0	0	0	0	0	0	0	0	0	0	0	0			
	14-20	0	0	0	0	0	0	0	0	0	0	0	0	0			
	21-27	0	0	0	0	0	0	0	0	0	0	0	0	0			
Jan/Feb	28-03	0	0	0	0	0	0	0	0	0	0	0	0	0			
	04-10	0	0	0	0	<1	0	0	0	0	0	0	0	0			

^{a/} f=*furens*; h=*hollensis*; me=*mellus*

Table 1.--Continued. Avg. no. (per trap/night) of *Culicoides* spp. collected at 4 locations at Parris Island, South

Carolina		Number of <i>Culicoides</i> ^a at indicated location											
Trapping dates :		Horse Island :			Elliot Beach :			Rifle Range :			Gardens :		
Date 1981		f	h	me	f	h	me	f	h	me	f	h	me
Jan/Feb													
11/17		0	0	0	0	<1	0	0	0	0	0	0	0
18/24		0	0	0	0	<1	0	0	0	0	0	0	0
Feb/Mar													
25-03		0	0	0	0	<1	0	0	0	0	0	0	0
04-10		0	<1	0	0	<1	0	0	0	0	0	0	0
11-17		0	5	0	0	8	0	0	4	0	0	0	0
18-24		0	5	0	0	6	0	0	4	0	0	2	0
Mar 25-31		0	1559	112	0	321	55	0	10	0	0	30	<1
Apr 01-07		0	6016	84	0	1048	22	0	635	5	0	26	0
08-14		2	4093	505	0	1574	105	<1	2525	60	0	36	0
15-21		155	730	557	723	2294	1082	144	535	199	8	32	11
22-28		87	317	806	2954	646	1007	937	3133	2902	15	71	6
Apr/May													
29-05		70	623	255	458	842	690	29	496	49	2	49	<1
06-12		33	66	43	1426	226	36	46	57	25	8	4	0
13-19		77	65	20	607	194	135	56	17	16	8	2	<1
20-26		545	91	195	2493	452	393	817	109	111	41	6	14
May/June													
27-02		48	0	19	687	112	16	227	7	10	3	<1	0
03-09		7	0	4	230	<1	1	22	3	2	3	<1	<1
10-16		19	0	39	362	3	266	96	0	8	14	<1	<1
17-23		4	0	4	328	0	19	3	0	0	<1	0	<1
24-30		6	0	18	1677	0	23	7	0	0	3	0	<1
July 01-07		10	0	22	42	0	<1	<1	0	0	0	0	0
08-14		19	0	12	190	0	9	23	0	3	8	0	1
15-21		31	<1	6	255	0	6	<1	0	0	0	0	0
22-28		23	0	7	455	0	5	9	<1	<1	6	0	2

Table 1.--Continued. Avg. no. (per trap/night) of *Culicoides* spp. collected at 4 locations at Parris Island, South Carolina

Date 1981	Number of <i>Culicoides</i> ^{a/} at indicated location															
	Trapping dates				Horse Island				Elliott Beach				Rifle Range			
	f	h	me		f	h	me		f	h	me		f	h	me	
July/Aug 29-05	39	0	2	76	0	0	<1		1	0	0		<1	0	0	<1
06-12	79	0	10	b/	b/	0	b/		22	0	10		181	0	11	
13-19	83	0	4	583	0	17			9	0	0		<1	0	0	
20-26	52	0	0	26	0	0			9	0	1		<1	0	0	
Aug/Sept 27-02	21	0	<1	1660	0	<1			10	0	<1		4	0	0	
Sept. 03-09	313	0	164	3820	0	3820			17	0	4		8	0	0	
10-16	38	<1	5	27	<1	2			5	<1	0		5	0	0	
17-23	3	0	0	26	<1	<1			<1	0	0		0	0	0	
24-30	30	26	14	865	123	19			2	5	0		9	25	<1	

^{a/} f=*furens*; h=*hollensis*; me=*melleus*

^{b/} Power line was down for the week.

Table 2.--Avg. no. (per trap/night) of major *Culicoides* spp. collected at 2 locations at Yankeetown, Florida.

		Number of <i>Culicoides</i> ^{a/}											
		Trailer						Bonita Club					
:	:	mi	:	f	:	b	:	mi	:	f	:	b	
Trapping : # :													
Dates : days :													
1980													
Oct	02-07	:	5	:	<1		11		<1		0		0
	07-15	:	8	:	8		29		0		64		4
	15-22	:	7	:	7		4		1		35		16
	22-29	:	7	:	510		41		5		-- b/		-- b/
Oct/Nov													
	29-05	:	7	:	1899		58		24		1122		49
	Nov 05-12	:	7	:	827		8		8		69		2
	12-19	:	7	:	1244		7		3		90		1
	19-26	:	7	:	357		0		<1		127		<1
Nov/Dec													
	26-03	:	7	:	594		<1		1		77		0
	Dec 03-10	:	7	:	276		0		0		1		0
	10-17	:	7	:	194		0		0		<1		0
	17-24	:	7	:	16		0		0		0		0
	24-31	:	7	:	7		0		0		0		0
1981													
Dec/Jan													
	31-07	:	7	:	5		0		0		0		0
	07-15	:	8	:	4		0		0		0		0
	15-21	:	7	:	18		0		0		0		0
	21-28	:	7	:	14		0		0		<1		0
Jan/Feb													
	28-05	:	8	:	58		0		0		0		0

Table 2.--Continued

		Number of <i>Culicoides</i> a/									
Location		Trailer					Bonita Club				
Species a/		ml	f	b		ml	f		b		
Trapping : # :											
Dates : days :											
Feb 05-13 :	8 :	169	0	0		<1	0		0		0
13-18 :	5 :	329	0	0		3	0		0		0
18-25 :	7 :	670	0	0		<1	0		0		0
Feb/Mar											
25-04 :	7 :	190	0	0		<1	0		0		0
Mar 04-11 :	7 :	142	0	0		<1	0		0		0
11-18 :	7 :	47	0	0		0	0		0		0
18-25 :	7 :	63	0	0		-- b/	-- b/		-- b/		-- b/
Mar/Apr											
25-08 :	14 :	--	--	--		--	--		-- c/		-- c/
Apr 08-15 :	7 :	203	2	2		<1	0		0		0
15-21 :	6 :	117	9	2		<1	0		0		0
21-27 :	6 :	182	16	9		0	0		0		0
Apr/May											
27-04 :	7 :	170	55	4		0	0		0		0
May 04-20 :	16 :	322	188	11		1331	76		131 d/		131 d/
20_27 :	7 :	1016	281	26		2120	277		536		536
May/June											
27-03 :	7 :	--	--	-- e/		2360	917		260 f/		260 f/
Jun 03-11 :	8 :	--	--	--		--	--		-- f/		-- f/
11-25 :	14 :	56	73	1		19	102		<1		<1
Jun/July											
25-01 :	6 :	27	431	1		13	102		5		5
Jul 01-08 :	7 :	3	155	156 b/		2	4		5		5
08-15 :	7 :	--	--	--		2	5		7		7
15-22 :	7 :	3	30	2		2	3		7		7

Table 2.--Continued

Location :		Number of <i>Culicoides</i> ^{a/}									
Species ^{a/} :		Trailer :					Bonita Club :				
Trapping : # :		mi	:	f	:	b	:	f	:	b	:
Dates :days :		mi	:	f	:	b	:	f	:	b	:
Jul 22-29 :	7 :	<1	:	420	:	19	:	1114	:	217	:
Jul/Aug 29-05 :	7 :	0	:	44	:	4	:	260	:	36	:
Aug 05-11 :	6 :	3	:	558	:	9	:	165	:	23	:
11-18 :	7 :	8	:	85	:	2	:	38	:	<1	:
18-26 :	8 :	<1	:	219	:	4	:	0	:	0	:
Aug/Sept 26-02 :	7 :	3	:	247	:	3	:	0	:	0	:
Sept 02-09 :	7 :	1	:	74	:	76	:	0	:	0	:
09-16 :	7 :	19	:	387	:	11	:	0	:	0	:
16-23 :	7 :	9	:	29	:	2	:	<1	:	<1	:
23-30 :	7 :	23	:	199	:	1	:	9	:	1	:
Total		364									

Footnotes for Table 2.

^{a/} mi=*mississippiensis*, f=*furens*, b=*barbosai*^{b/} trap malfunction/vandalism

^{c/} During this period, traps were converted from dry (DDVP) to wet (isopropanol) collecting chambers. The number of flies wet-trapped was so great as to make sample counts impractical. Traps were therefore reconverted to original dry collecting and samples from this period (incompatible numerically with previous dry sample counts) were discarded.

^{d/} Bad batch of DDVP suspected for previous one-month's data for Bonita Club trap.

^{e/} gummy residue from trapped Coleoptera rendered sample uncountable.

^{f/} samples destroyed by heavy showers, approximately 500 total count.

Table 3.--Minor *Culicoides* spp.^{a/} recorded from Yankeetown, Florida during October, 1980 - September, 1981.

C. arboricola Root and Hoffman
C. baueri Hoffman
C. bermudensis Williams
C. edeni Wirth and Blanton
C. floridensis Beck
C. guttipennis (Coquillett)
C. haematopodus Mallock
C. hinmani Khalaf
C. insignis Lutz
C. loughnani Edwards
C. niger Root and Hoffman
C. ousairani Khalaf
C. paraensis (Goeldi)
C. stellifer (Coquillett)
C. villosipennis Root and Hoffman

^{a/} These species comprise <1% of total trap catches

Table 4.--Comparison of trapping techniques at Parris Island, South Carolina

Season	Species	Mean No. adults collected/trap/night				
		No trap days	CDC-UB	CDC-B	NJ	Malaise
Oct-Dec 1980	<i>hollensis</i>	41	23.6	--	352	--
	<i>melleus</i>	41	20.9	--	55.2	--
	<i>furens</i>	41	39.6	--	135.1	--
Mar-Apr 1981	<i>hollensis</i>	33	19.7	1081.4	935.7	209.2
Apr-Jul 1981	<i>furens</i>	39	16.1	462.4	502.5	10.9

Table 6.--Mean No. *Culicoides* larvae recovered from soil samples taken in major vegetative zones, Yankeetown, Florida, 1980-1981.

		Number Larvae Recovered											
Year :	80	80	80	81	81	81	81	81	81	81	81	81	81
Location: Month:	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sep
1. <i>Juncus</i>	3.7	3.3	4.4	4.0	4.8	4.3	9.0	8.3	15.2	9.9	11.9	9.4	9.4
2. <i>Spartina</i>	5.9	3.5	9.8	12.8	11.2	10.5	9.8	12.8	10.1	11.8	12.8	12.2	12.2
3. <i>Distichlis</i>	9.4	6.7	7.2	6.7	17.9	13.3	9.5	14.6	23.1	5.5	17.3	7.0	7.0

Table 7.--Meteorological Data for Spray Operations Over Parris Island, South
Carolina, April 7, 1981. a/

<u>SURFACE OBSERVATIONS</u>			
	<u>1700L</u>	<u>1730L</u>	<u>1800L</u>
Cloud Cover	10/10/CI/CS 25,000'	10/10/CI/CS 25,000'	10/10/CI/CS 25,000'
	8/10 opaque	8/10 opaque	7/10 opaque
Temp	62°F	61°F	60°F
Wet Bulb	52°F	52°F	52°F
Dew Point	49°F	50°F	51°F
Relative Humidity	50%	51%	58%
Wind Drctn	090°	080°	090°
Speed (kts)	07	07	07
Winds	Start of		
Aloft	Spray Ops (H-30)	H+00	H+30
Sfc-100'	108°/6.7KTs	095°/12.5KTs	090°/11KTs
Sfc-200'	101°/7.8KTs	095°/13.0KTs	102°/14KTs
Sfc-300'	100°/8.8KTs	095°/14.0KTs	101°/16KTs
Pasquill	1700L	1730L	1800L
	E	E	E
Time of Sunset	1847L		

a/ Data observed and compiled by MGySgt K. L. Hicks

Marine Corps Air Station

Beaufort, South Carolina 29904

DATE
FILMED
8